Jeremy Andrus

Jason Nieh

Columbia University

in the city of new york

Student Response

Assignments

The Course

- one semester introductory OS
- graduate / advanced undergrad
- students familiar with C
- no previous kernel development experience
- teams of 2-3 students

Android

- uses Linux kernel: familiar transition path

Android

- leverages wealth of Linux tools/documentation

Android

- open source (mostly)

Android

- production system

Android

- fastest growing mobile platform to date

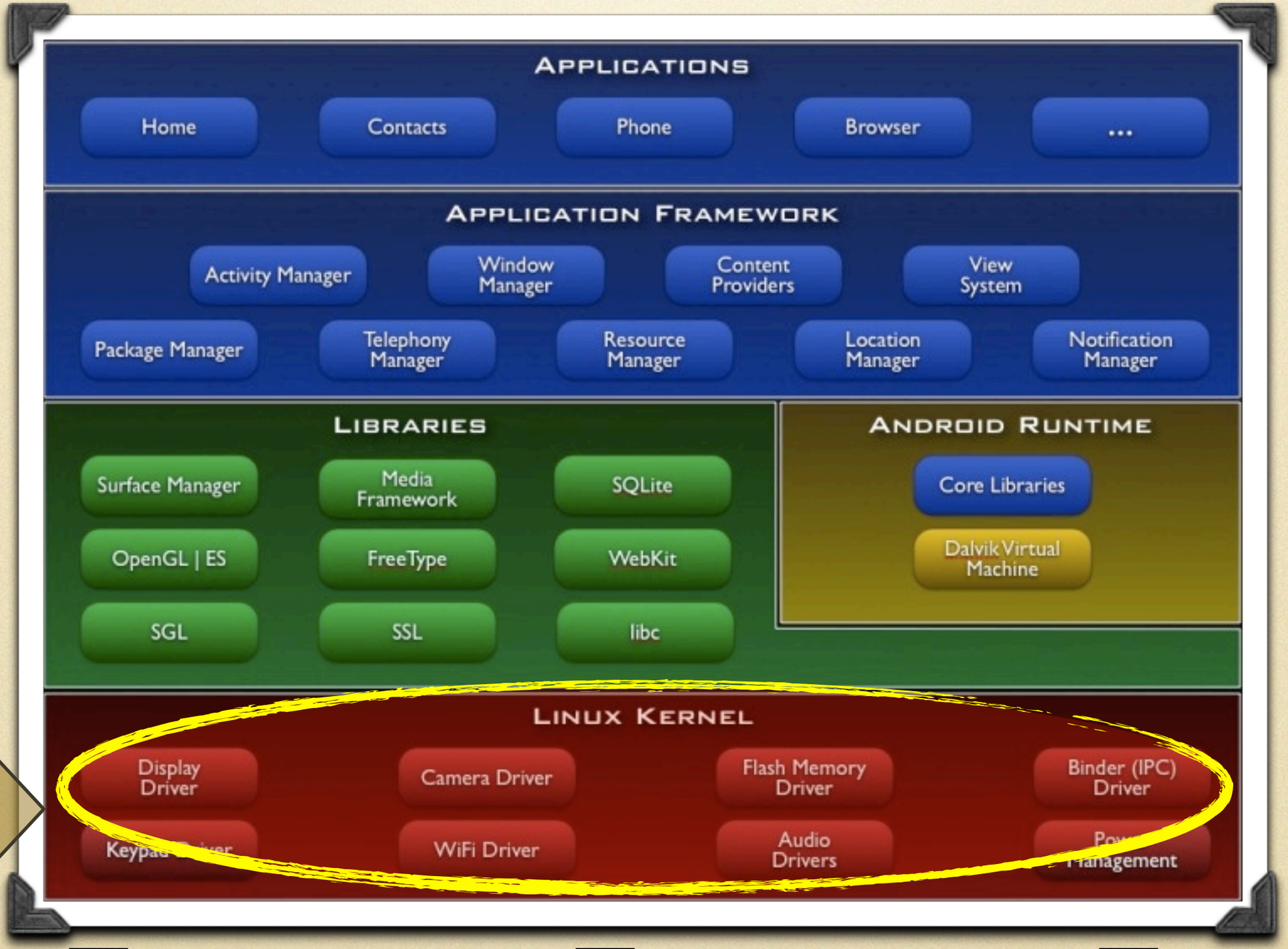
Android

- commercially supported

Android

- hacking your phone is cool

Android Inside



OS: C C/C++ Java

Overview

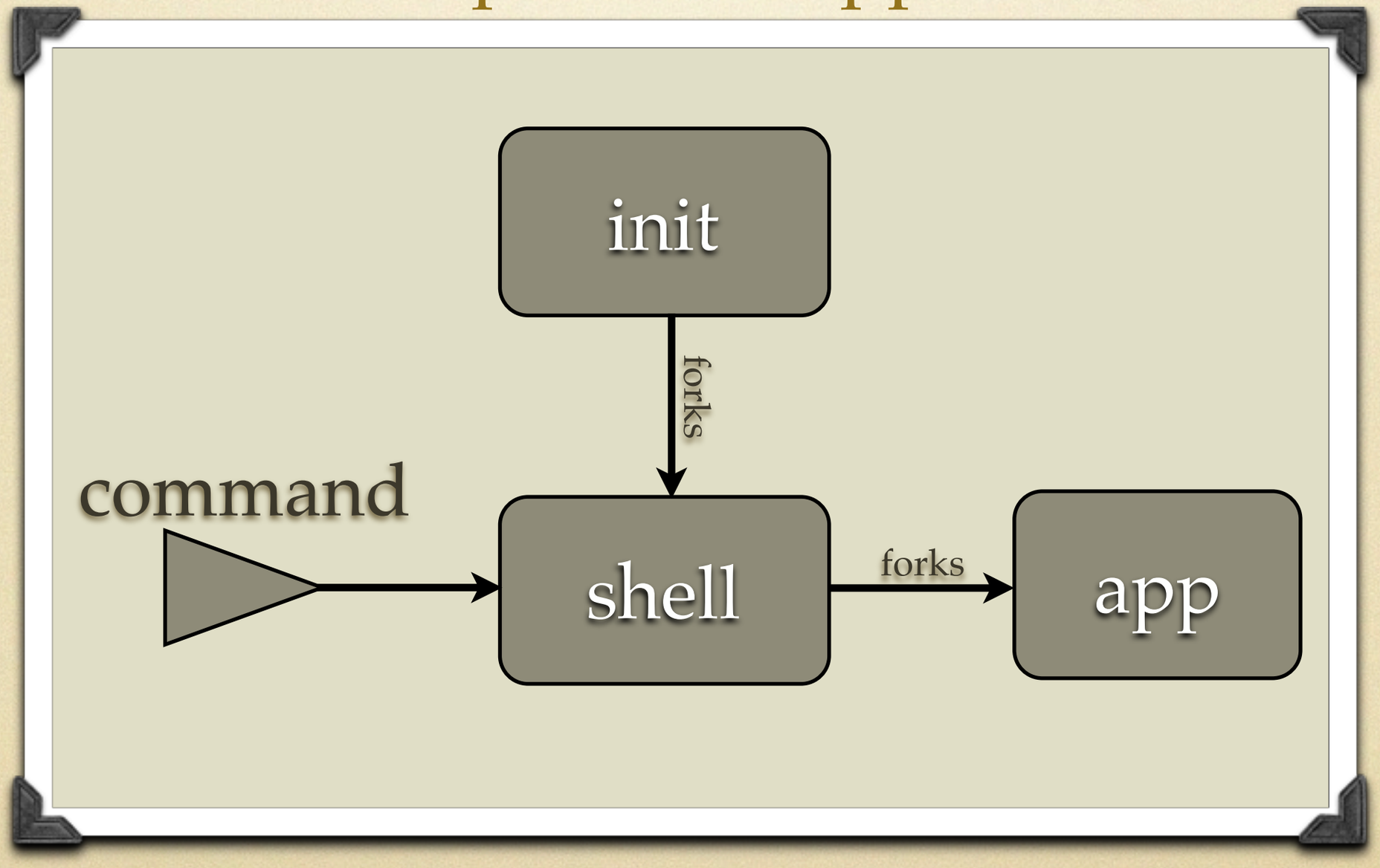
- system calls / processes : zygote / Java workers
- synchronization : device sensors
- scheduling : display-prioritized scheduling
- virtual memory : COW multi-process working set
- file systems : auto geo-tagging

Overview

- system calls / processes
- synchronization
- scheduling
- virtual memory
- file systems

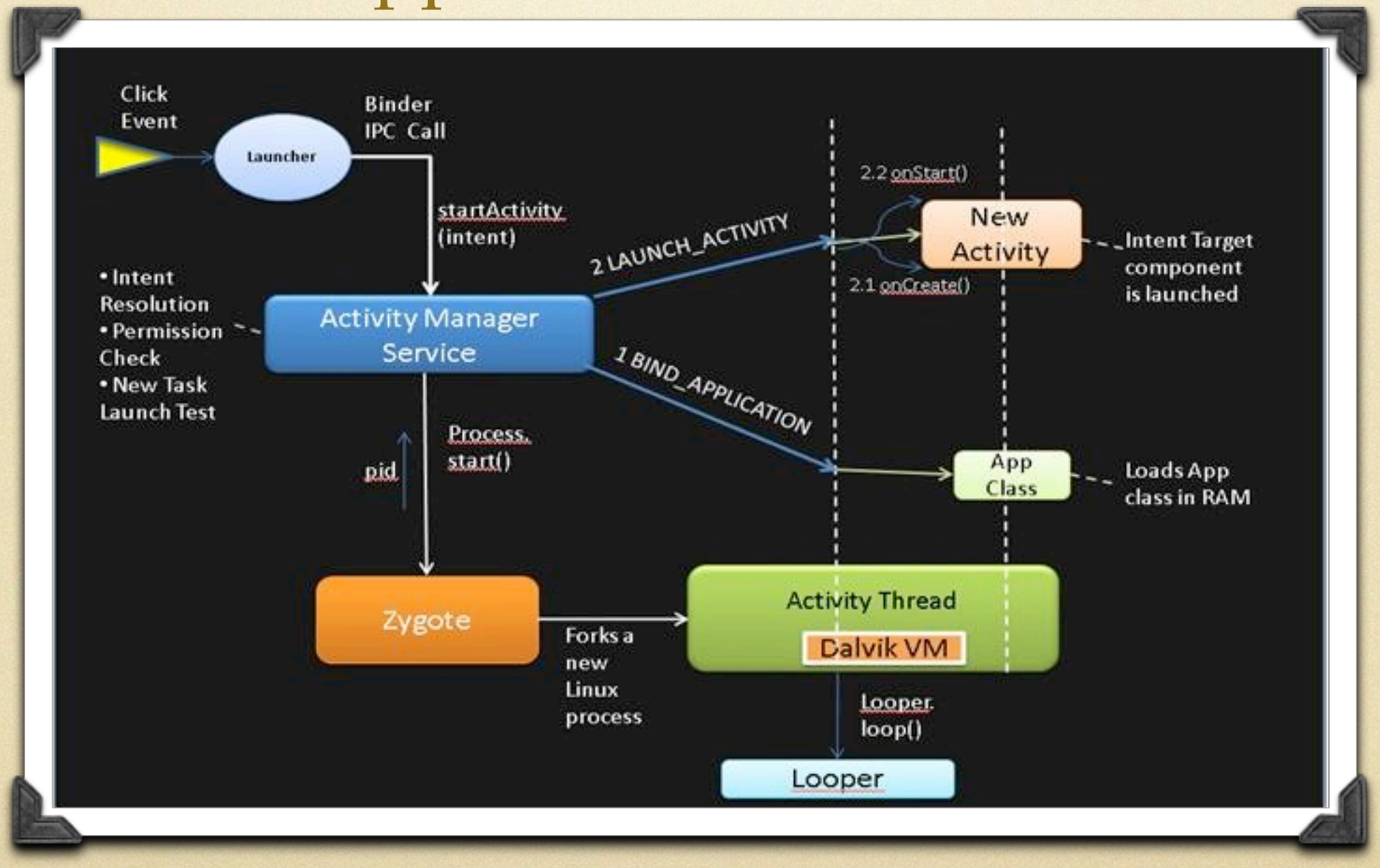
System Calls / Processes

Linux desktop/server application start:



System Calls / Processes

Android application start:



System Calls / Processes

- new system call
- return process tree in DFS order
- simple user space test program
- reflect on benefits of zygote process

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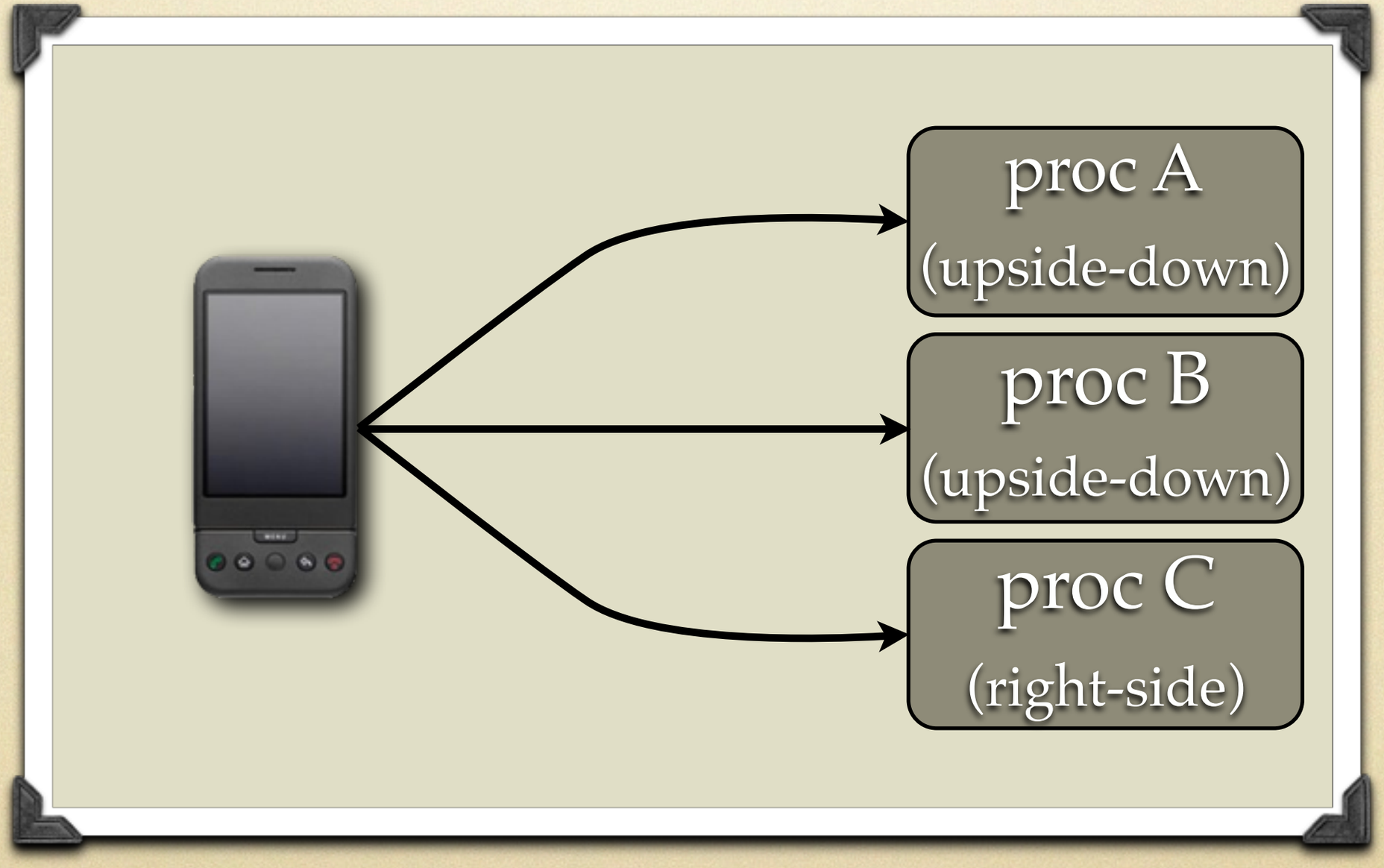
Synchronization



Synchronization

- user space daemon to read orientation (library)
- new syscall to update orientation in kernel
- new orientevt open/close/wait syscalls
- investigate HAL layer, use real sensor data

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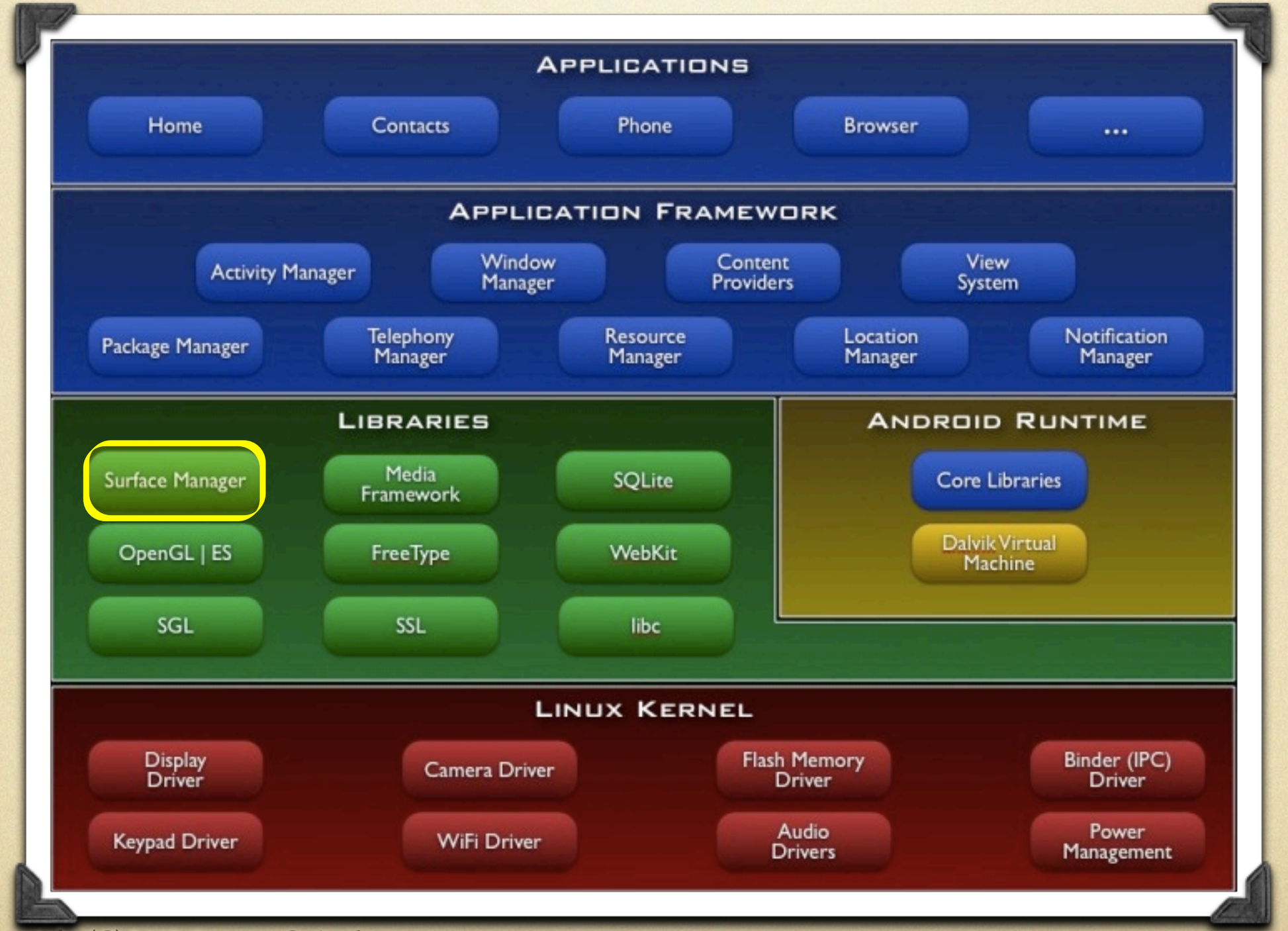
Scheduling



Scheduling

- drawing == interactive
- display boosted multi-level container (DBMC)
- 15-line patch to core Android drawing library
- GUI boots 5-10s faster / network is slower

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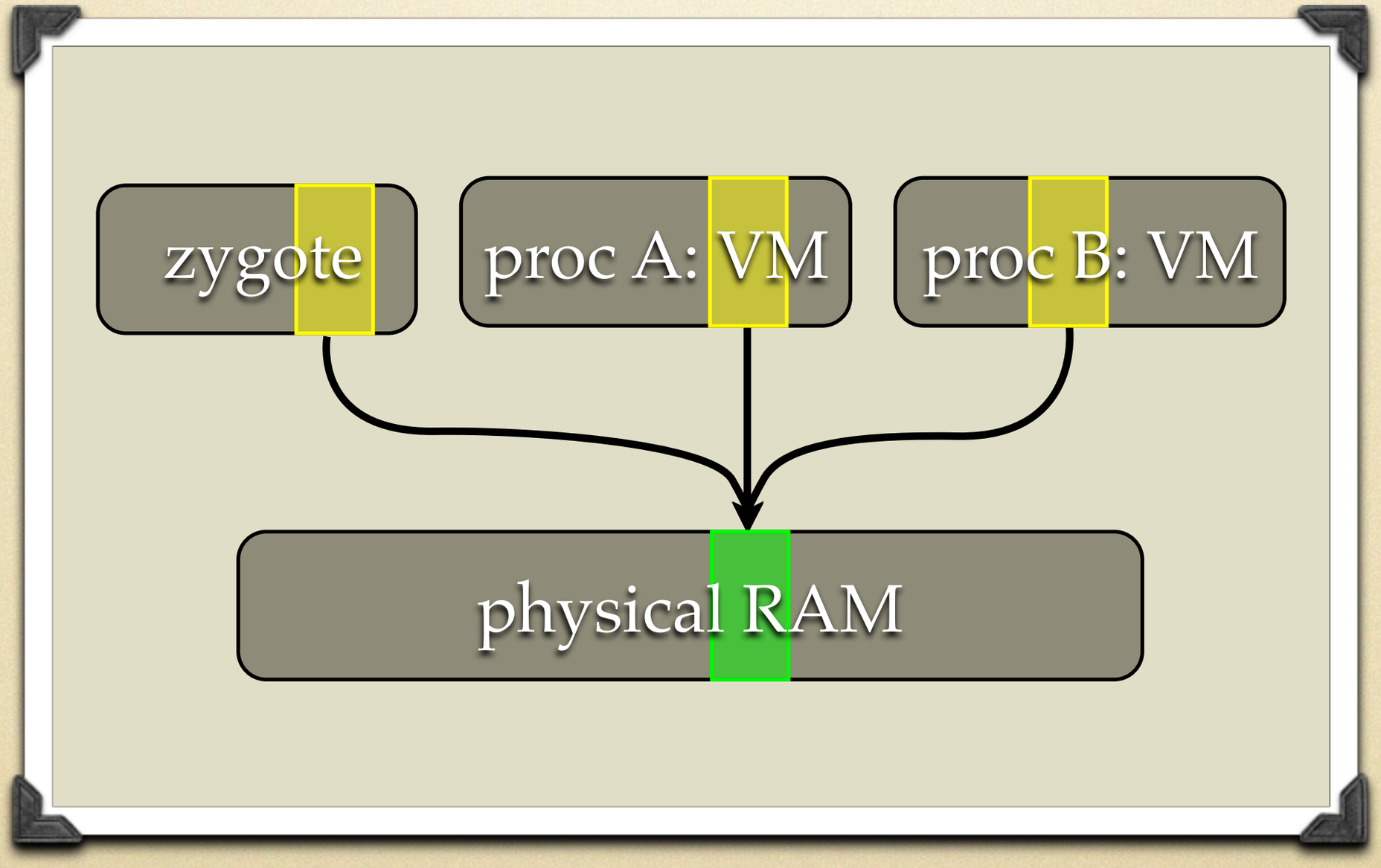
Virtual Memory



Virtual Memory

- zygote: quiescent VM waiting to be forked
- Android apps are forked from zygote
- cross-process working set: COW pages from zygote
- lots of shared memory + faster app startup

Overview

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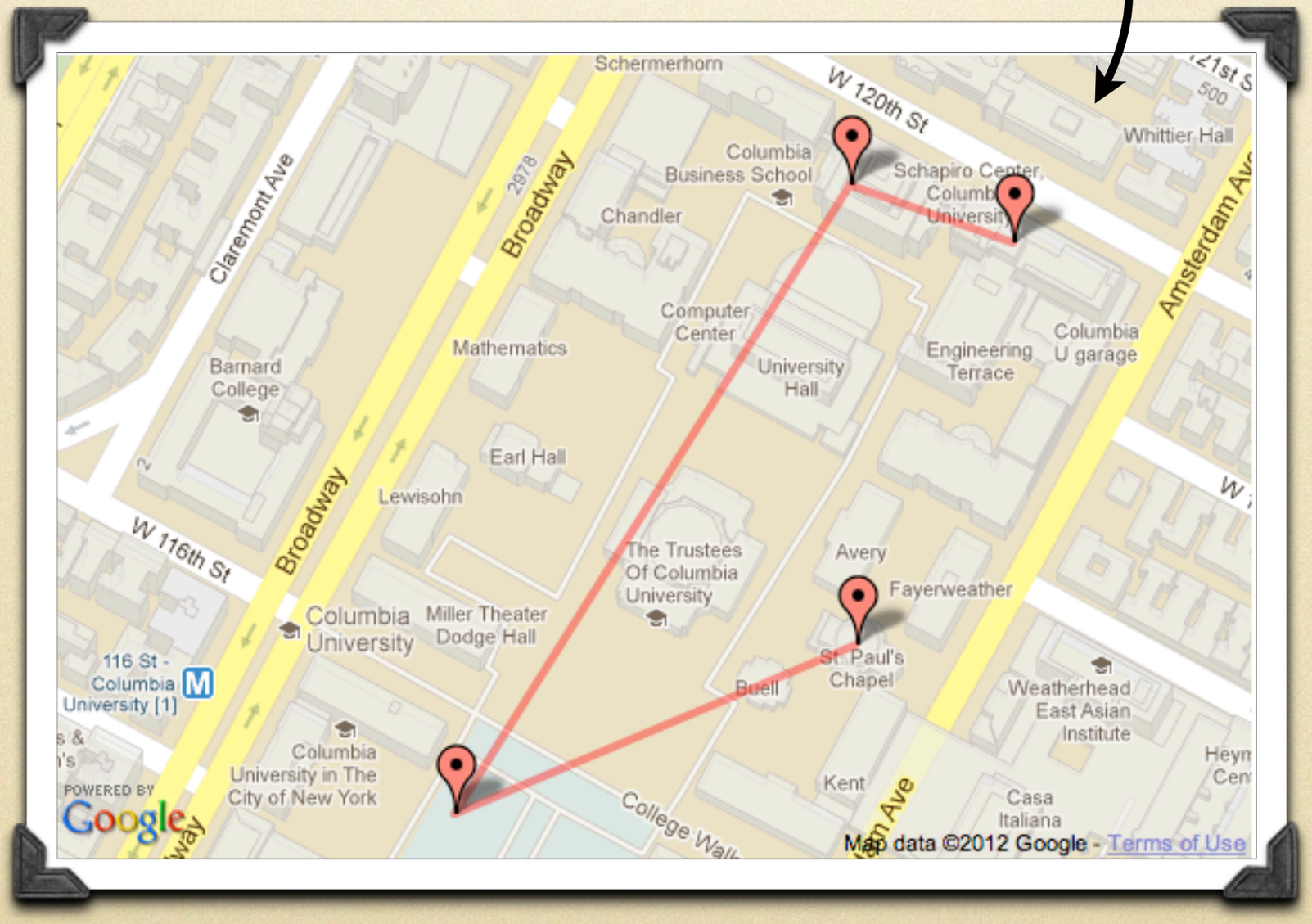
File Systems

```
echo “HERE” > `date +”%s”`.txt
```

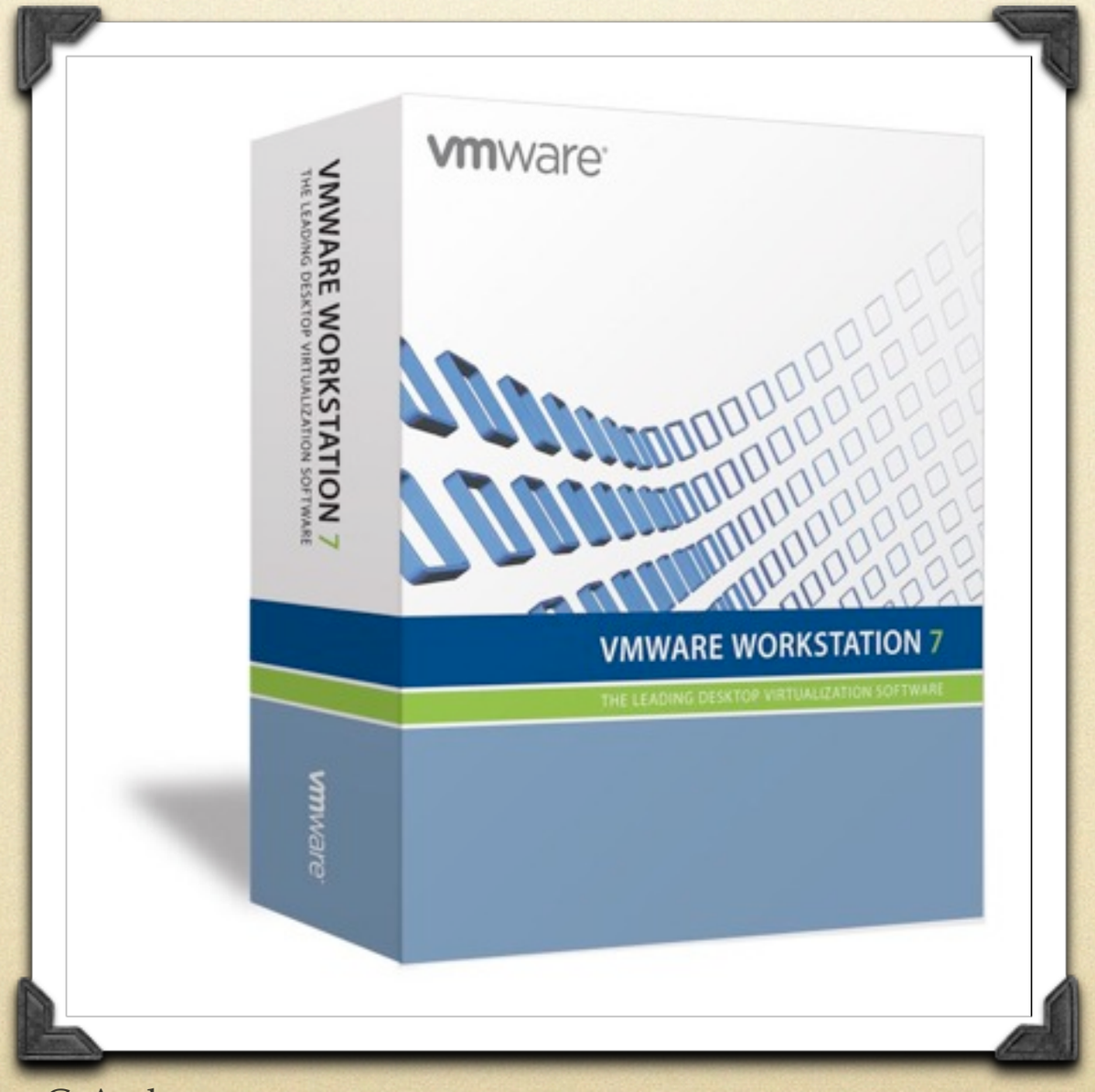


File Systems

- user space daemon updates GPS coordinates
- modify ext2 file system
- last-known GPS location on create/modify
- Google Maps link using system call to retrieve geo-location

Virtual Machines

fully-configured cross-compilation tools



Real Cell Phones

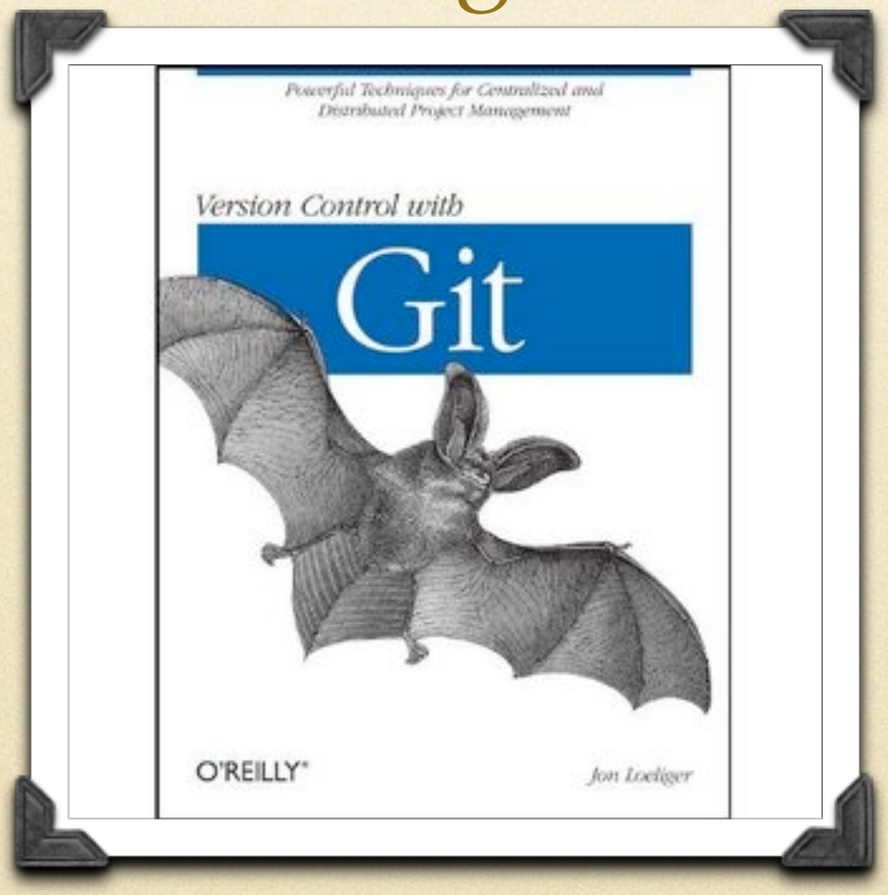
Unlocked Google ADP1 (T-Mobile G1)

Full-System Emulator

QEMU based program bundled with Android SDK!

git

production grade SCM



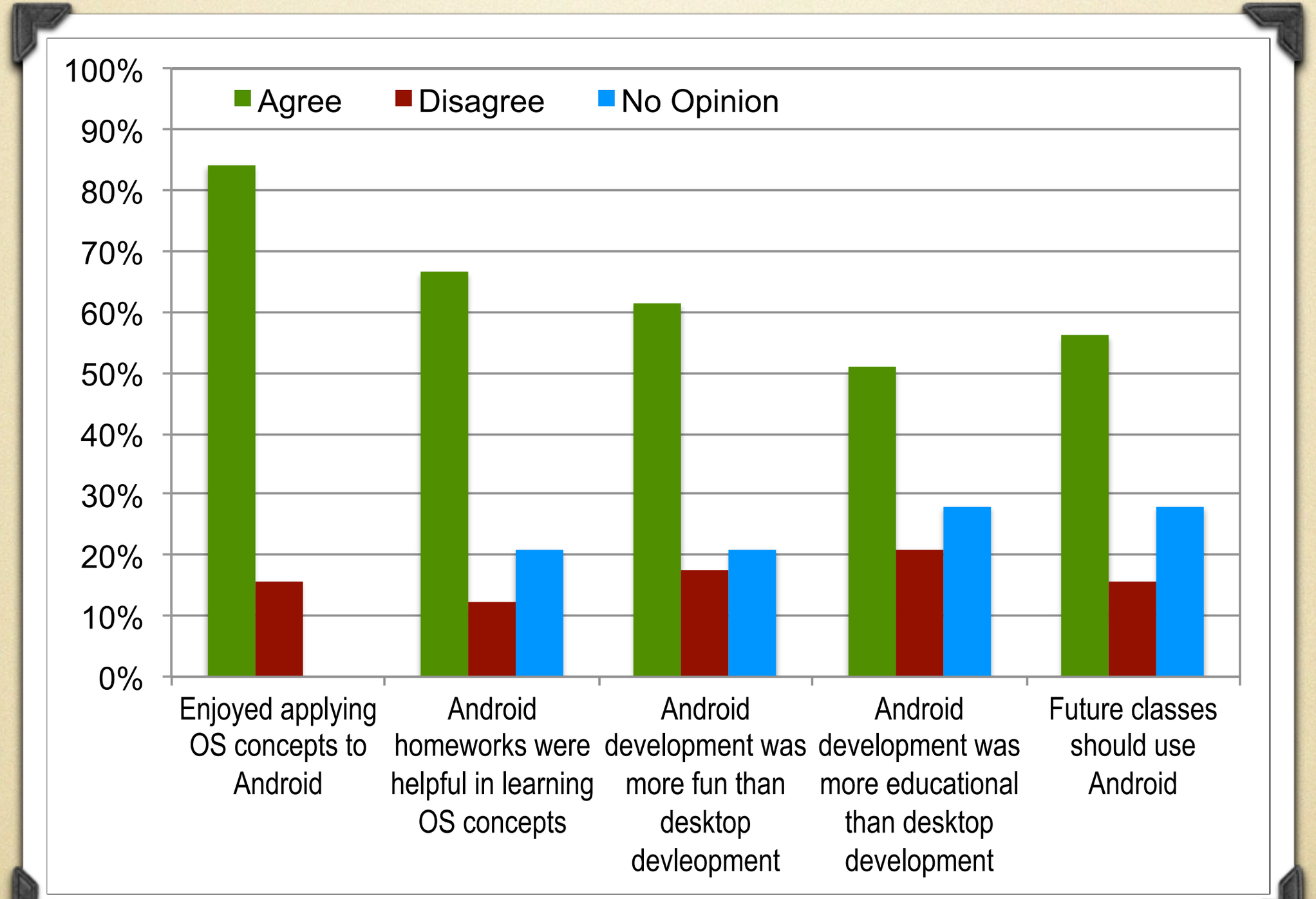
Show Your Work

- hour-long demo slots (3-4 teams)
- clone and build: your kernel must boot!
- code review
- demonstrate fully-functional solution

The Course

- deployed kernel assignments, virtual lab
- ~100 students: undergrad through PhD
- transitioned from Linux to Android
- end of semester survey

Survey Results



Lessons Learned

- test before distributing assignments
- difficult to keep emulator / device in sync
- need clear Android kernel debug documentation
- Android constantly evolves

Conclusions

- Android is a great teaching tool
- Android / mobile programming assignments
- Android virtual lab
- live demos

Conclusions

- practical application outside classroom
- can write “android development” on resume
- students loved it!

http://systems.cs.columbia.edu/projects/teach-os/

http://www.cs.columbia.edu/~nieh/teaching/w4118/